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High-speed Solar Wind Streams Associated Changes in Cosmic Ray Intensity as well as in Geomagnetic Activity

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ABSTRACT

In this study, we have selected the 193 events of HSSWS using hourly plots of interplanetary solar plasma parameters for the period of 2001 to 2009,which cover the descending phase of the solar cycle 23. We have selected HSSWS as one having a rapid rising increase in the solar wind speed over a short period reaching a maximum value of $\geq$ 450 kms^{-1}, which persist at high values for at least three days after the increase. We have also separated these HSSW Streams into two categories: (i) Flare generated (FGS) and (ii) Coronal hole associated (CS) Streams. The result indicates that the flare-generated HSSWS are more effective in producing cosmic ray decreases and the geomagnetic disturbance than the corotating HSSWS. The result also shows that the flare-generated HSSWS of occurrence duration is 4 days is more effective in producing large depression in cosmic ray intensity.

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Keywords: High-speed solar wind streams, cosmic rays, coronal hole etc.

INTRODUCTION

High-speed solar wind streams (HSSWS) are known as a most dynamical feature in interplanetary medium. Periodic HSSWS have been known to exist since research by Snyder *et al.*[1]. Several researchers have studied the characteristics

of these HSSWS giving various definitions of them (Intriligator[2,3]; Gosling *et al.*[4]; Iucci *et al*.[5] 1979). Krieger *et al.*[6]) demonstrated that the source of solar wind streams were coronal holes. Iucci *et al.*[5] and Shukla *et al.*[7] (1979) have shown that the close correspondence between the cosmic ray intensity decreases observed by high HSSWS produced by solar flares accompanied by Forbush decreases. Venkatesan *et al.*[8] observed differences in the rigidity spectrum of the short-term variation of cosmic-ray intensity, which is attributed to the two types of HSSWS of different origin. This difference in the rigidity spectrum of cosmic-ray intensity has implications on the understanding of both the short-term and the long-term variations of cosmic-ray intensity.

On the basis of different physical features, two types of HSSWS have been identified (Mavromichalaki *et al.*[9] 1988). The first kind is a long-lasting HSSWS emitted by coronal holes that exhibited an apparent tendency to recur at interval of ~27 days – the so called corotating streams or coronal hole associated streams (CS) and the second one, characterized by lower solar wind speed seems to be associated with strong active regions emitting solar flares and producing Forbush decreases at the Earth – the so called flare generated streams (FGS). Solar wind plasma streams with high velocity were investigated as one of the important factor in cosmic-ray modulation (Mishra *et al.*[10] 1990; Shrivastava and Shukla[11] 1994).The passage towards the Earth of these two types of HSSWS leads to enhance the level of geomagnetic activity and in general, a short term changes in cosmic-ray intensity (Shrivastava and Shukla[12], 1993).Snyder *et al.*[1] (1963) showed a possible link between interplanetary solar wind speed V and geomagnetic index K_p, such a relationship has been examined by many workers and found to rather loose. Sheeley *et al.*[13] (1976) have reported that the corotating HSSWS were the cause of the recurrent geomagnetic activity at the Earth.

DATA ANALYSIS

In this work, we have studied the effect of these two types of HSSWS on cosmic-ray intensity as well as on geomagnetic activity for the period of 2001 to 2009.Which cover the descending phase of the solar cycle 23. We have selected 193 HSSWS, starting from the year 2001 to 2009. Out of these 117 events are found CS events and 76 are found FGS events. The velocity profile of HSSWS as well as solar wind and geomagnetic indices data was obtained from the website http://nsdc.gsfc.nasa.gov/omniweb/.

We have selected the events of HSSWS using the plot of hourly values of interplanetary parameters. The same criteria, which were reported by Mavromichalaki *et al.*[9] have been adopted for the selection and identification of these HSSWS. We have selected HSSWS as one having a rapid rising increase in the solar wind speed over a short period reaching a maximum value of $\geq$ 450 kms^{-1}, which persist at high values for at least three days after the increase. We have adopted the Chree method of superposed epoch to determine the average behavior of cosmic-ray intensity, using the daily mean values of Kiel neutron monitor (154ºN, 114ºW cut off rigidity Re=2.32 GV) and geomagnetic activity.

RESULT AND DISCUSSION

Several investigators have indicates the presence of the two types of HSSWS and their effect on cosmic-ray intensity variations (Venkatesan *et al.*[8], 1982; Shrivastava and Agrawal[14], 1990; Mishra *et al.*[10], 1990) These results are based on the dominance of corotating streams during low solar activity periods (Zirker[15], 1977; Hundhausen[16], 1979) and the dominance of flare-generated streams during high-solar activity period. In this study we have plotted yearly histograms of the HSSWS for all the streams, corotating and flare-generated streams as shown in Figure 1.Fig. 1 shows that the number of corotating streams is greater than the number of flare generated streams particularly during the descending phase of the solar cycle 23.We have also plot the result of Chree analysis for the period of 2001-2009 as shown in Fig. 2. The decrease starts from -1 day and reaches to maximum on +1 day. It is observed from the Figure that both type of streams are capable in producing short term transient decrease in cosmic ray intensity, which support the earlier findings of Shrivastava and Jaiswal[17] (2003). The result also indicates that the flare-generated HSSWS are found to be more effective in producing cosmic ray decreases incomparision to the corotating HSSWS. We have done similar Chree analysis as taking the geomagnetic Dst values as shows in Figures 3 and 4. It is clear that CS and FGS both types of stream produce increase in geomagnetic activity. However average profiles shows slightly higher increase during FGS streams. Further, we have grouped these HSSWS on the basis of their occurrence time in 3 days, 4 days, 5days, 6 days and more than 6 days. The result of Chree analysis is plotted in Figure 5. Our study reveals that the FGS of occurrence duration is 4 days is capable producing more depression in cosmic ray intensity than another.

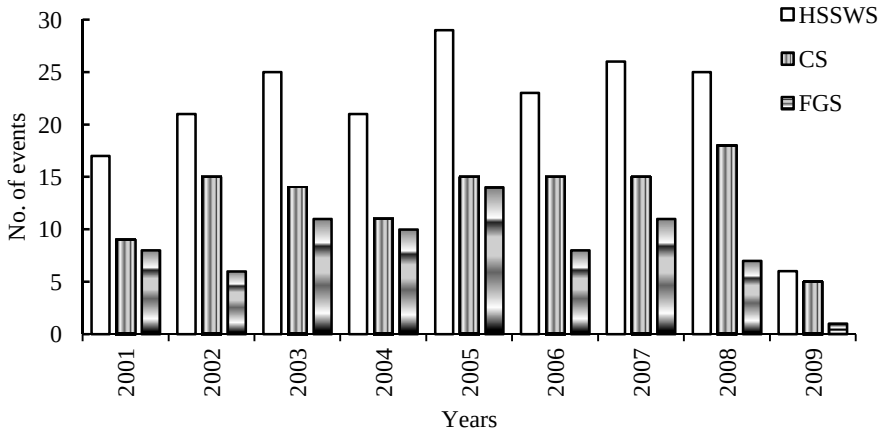

Figure 1 Histogram showing the distribution of HSSWS for the period of 2001-2009

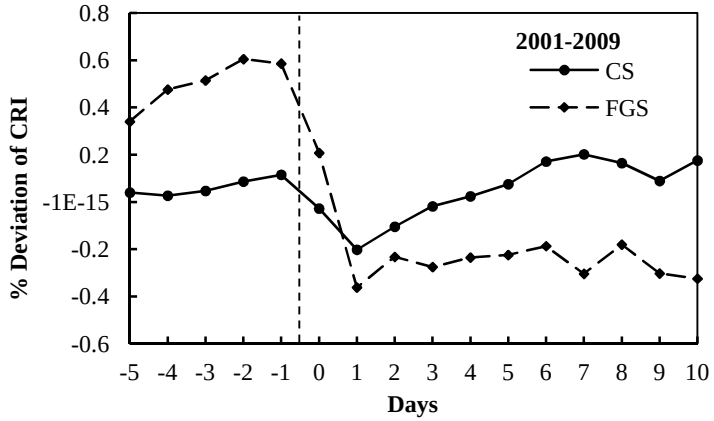

Figure 2 The result of Chree analysis of superposed epoch from -5 to 10 days w.r.t. zero epoch days for the period of 2001-2009

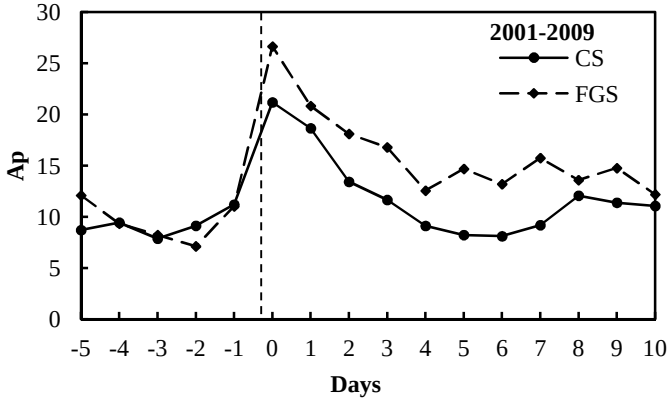

Figure 3 The result of Chree analysis of superposed epoch from -5 to 10 days w.r.t. zero epoch days for the period of 2001-2009

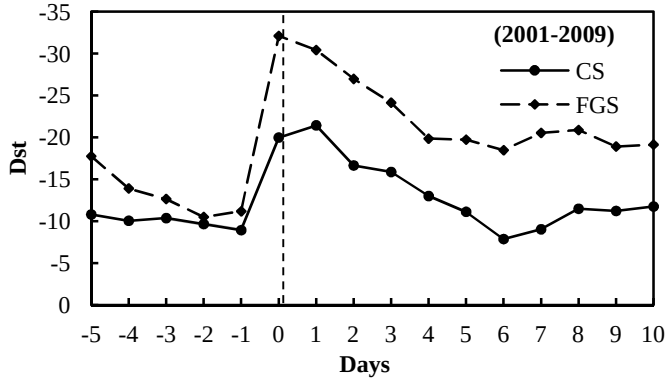

Figure 4 The result of Chree analysis of superposed epoch from -5 to 10 days w.r.t. zero epoch days for the period of 2001-2009

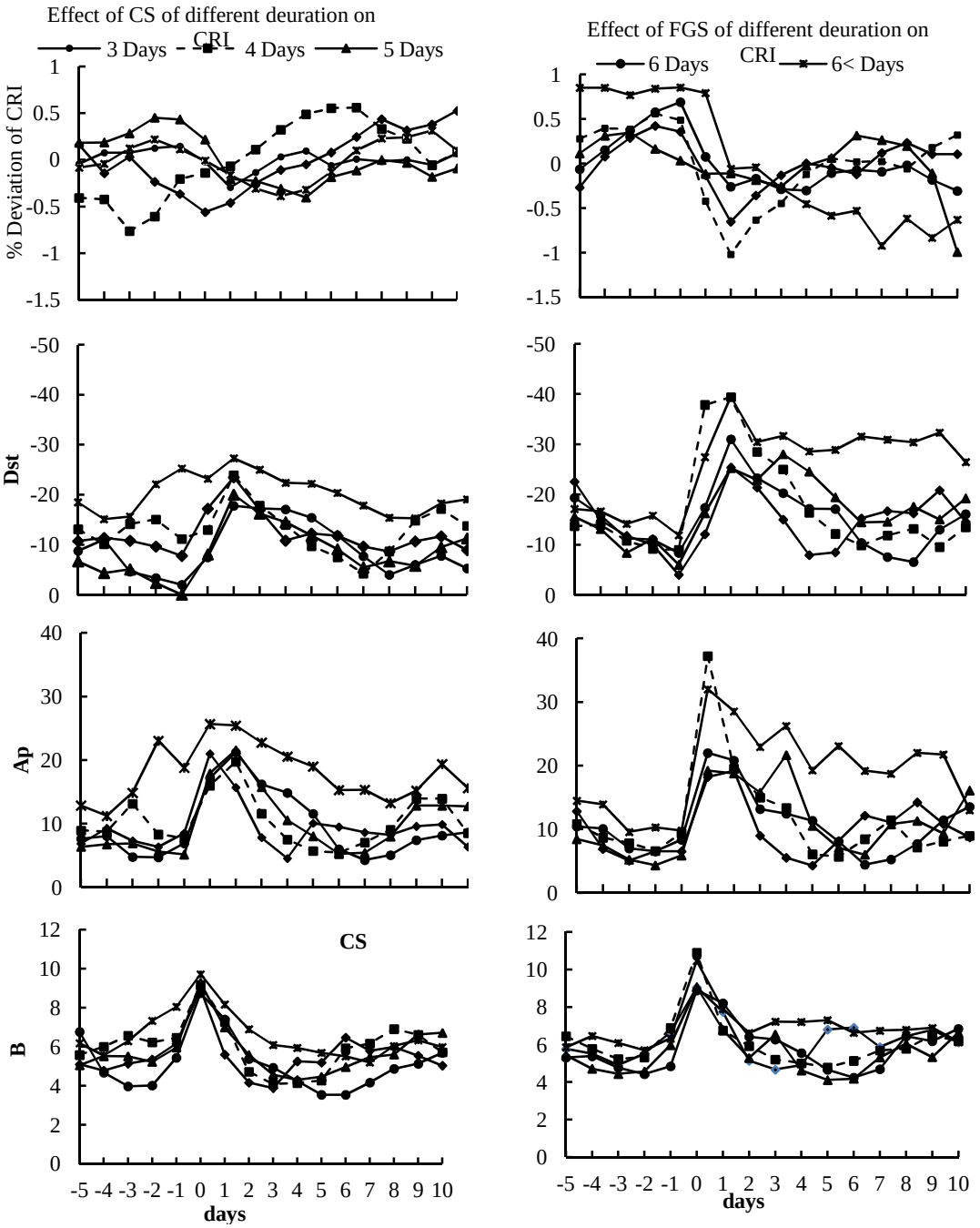

Figure 5 The result of Chree analysis of superposed epoch

CONCLUSION

1. The two types of solar wind streams produce significant deviations in cosmic ray intensity.
2. The flare-generated HSSWS are more effective in producing cosmic ray decreases and the geomagnetic disturbance than the corotating HSSWS.
3. The flare-generated HSSWS of occurrence duration is 4 days is produced large depression in cosmic ray intensity than another.

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